chapter of the work. The rest consists of a collection of medical receipts, differing from those in the other books of the Anglo-Saxon library. It is entirely free from charms and superstitions, and the prescriptions are for the most part simpler than those of the Anglo-Saxon leeches. This treatise has been shown by a German philologist, Dr. Max Löweneck, to be based upon a Latin work belonging to the first period of the school of Salerno—namely the Practica of Petroncellus or Petronius, a work written probably about A.D. 1035, and printed in the *Collectio Salernitana*. One fragment has been traced to the writings of another Salernitan teacher, Gariopontus, of the same period. But these identifications do not account for the whole of the Anglo-Saxon text, and it does not seem that this was translated directly from the Latin. The actual origin of the work is therefore still somewhat obscure.

The date of this manuscript is the first half of the twelfth century, probably before 1150. It shows that the Anglo-Saxons were beginning to profit by the teaching of the school of Salerno before that school was influenced by the Arabian medicine. It also shows that the Anglo-Saxon medicine, like the other early English written literature went on for some time after the Norman Conquest.

To this same period belongs another MS., which contains a version of the Herbarium of Apuleius later than that previously spoken of. This is not included in Mr. Cockayne's *Leechdoms*, but has been published in Germany, as edited by Herr Berberich. This MS. is referred to the middle of the twelfth century, about 1150. It therefore touches on the extreme limit of Anglo-Saxon written literature—and, indeed, is described by Herr Berberich as "early middle English"—but, like the last-mentioned work, shows the long continuance of Anglo-Saxon medicine after the Conquest.

This work closes the early English medical library, and, as the celebrated Anglo-Saxon Chronicle came to an end in 1155, the general literature and medical literature of our early ancestors reached their limit about the same time.

The Croonian Lectures

ON

MUSCULAR MOVEMENTS AND THEIR REPRESENTATION IN THE CENTRAL NERVOUS SYSTEM.

Delivered before the Royal College of Physicians of London.

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LECTURE IV.

[ABSTRACT.]

ASSOCIATION OF MUSCLES IN ACTION.

THE fixation action of muscles was described by John Hunter in his Croonian Lectures on Muscular Motion, delivered before the Royal Society in 1777,[1] where he stated that

> there is in every animal, therefore, a fixed point from which the parts of the body take their principal motions. In the human body this fixed point seems to be in the joints of the thigh bones, which point being in the middle of the body must be common to the extremities.......Besides this there are many fixed points, so that the body is to be looked upon as a chain of joints whose general centre of motion is in the joints of the thighs.

This centre of motion corresponds to the point of centre of gravity described by subsequent observers. The position of the fixed point depends on the attitude of the person and the place where his body comes in contact with the ground and where it gets a firm foundation. We have to distinguish in any movement between the muscles which take part directly in that movement and the muscles which are used to fix the joints which lie between the joint which is actively engaged and the fixed point or base on which the structure works. Again these fixing muscles have to be separated into those which always take part in the strong movements irrespective of the posture of the person, which we may call essential, and those which depend on the position of the person and where his fixed point or base is, which we may call postural. I should therefore describe the muscles taking part in any one movement as:

(A) Prime movers.
(B) Synergic muscles.
(C) Fixation muscles: (1) Indispensable or essential, (2) postural.
(D) Antagonist muscles in occasional movements.

The principal or prime movers are the muscles which directly produce the action required, and are called by some authors the "agonists"; the synergics are the muscles which, as I have previously stated, are brought into the combination when a prime mover has, by passing over two or more joints, two or more actions of which only one is required; the synergics neutralize these undesired actions. The fixation muscles, as I have already described them, are: (1) Those which are essential to the movement in all postures, and which are not influenced by the position of the person; and (2) those which only act to prevent the equilibrium of the trunk being disturbed by the movement, and which I have therefore called "postural." The antagonists produce the movement which is diametrically opposed to that of the prime movers.

[Dr. Beevor described and criticized the classifications of Winslow and Duchenne, and proceeded as follows:]

John Hunter[2] stated in his Croonian lectures that there is no one known muscle in the body that we can throw into action separately and independently of the collateral effects of others. Duchenne[3] has expressed the opinion that partial muscular contractions do not exist in Nature, that they are only produced artificially by means of faradization, and Dr. Hughlings Jackson has laid down the dictum that "nervous centres know nothing of muscles, they only know of movements." This in other words means that the ordinary individual has no power to make any one muscle contract by itself, he can on requiring to attain a certain object order a certain movement, but the mechanism by which that movement is produced and the muscles which are required to perform that movement, and the order in which they act is not known to the brain. Having illustrated this point by reference to the movements of extension of the wrist by means of the extensors of the fingers against resistance when the muscles came into action in a definite order, which apparently cannot be altered, and to the intimate association between the principal movers and the synergic muscles in the extension of the thumb, Dr. Beevor expressed the opinion that an individual has no power voluntarily to leave a muscle out of a combination to which it belongs.

Another question, he said, is, Is it possible to voluntarily add to the list of muscles which are told for a certain movement, or to supplement when one is paralysed? It has been said that the anterior portion of the deltoid can replace part of the functions of the pectoralis major, but it must be remembered that the only function to which this could refer would be the action of advancing or adducting the humerus, but the deltoid is naturally associated with the clavicular part of the pectoralis major in this movement, and if the pectoralis were paralysed by a peripheral lesion, the deltoid would continue to act exactly as before, the movement being imperfectly carried out; one muscle would not replace the other. On the other hand, when the muscles proper to the movement are paralysed, the difficulty may be overcome by a series of other movements. I remember seeing a case with paralysis of the flexors of the elbow in a man, who managed to produce flexion of the elbow by advancing the humerus, rotating it out, and by this means letting the fore-arm be flexed by gravity, but here the muscles were not supplemented by other muscles, but an entirely different group was thrown into action by which the desired change of position was obtained. I think, therefore, that although by exercise and training it may be possible to alter the arrangement of the muscles taking part in any movement, the inability of a patient with lead paralysis to induce the extensores carpi to act out of their proper order is against this possibilility. By mechanical means, such as transplantation of tendons, first recommended by Nicaladoni[4] in 1882, it is possible to take a muscle out of one group and put it into another, and I have had the opportunity of seeing the results of some of these cases under the care of Mr. Muirhead Little[5] and Mr. Tubby[6] at the National Orthopaedic Hospital.

From a consideration of the above statements I think that one is justified in saying that for every voluntary movement there is a definite number of muscles, usually two or more, which come into action in a definite order which cannot be altered, and the individual members of which cannot be omitted, and cannot be supplemented except perhaps by long training and exercise or by operative procedure. In every voluntary movement there is a minimal number of muscles which I would call the ultimate or the minimal components of a movement. Such ultimate components of the movement of extending the metacarpal bone of the thumb are the extensor ossis metacarpi pollicis, extensor carpi ulnaris, and, further on in the movement the flexor carpi ulnaris; and in the movement of extending the first phalanges of the fingers the extensores digitorum and flexores carpi.

CENTRAL NERVOUS REPRESENTATION.

There are three places in the central nervous system where these ultimate components of a movement may be represented, in the spinal cord corresponding to Dr. Jackson's lowest level, in the cerebral excitable cortex or so-called motor area (Dr. Jackson's middle level) or in the centres postulated to preside over the so-called motor area (Dr. Jackson's highest level). With regard to the last place I have no evidence to offer at present.

Representation in the spinal cord of the different muscles of the limbs has been studied both experimentally and clinically, and the first question that has to be answered is whether the grouping of the cells of the anterior horns of the spinal cord is of a morphological or a physiological type. In other words, whether in the brachial enlargement the cells which supply the muscles forming the ultimate components of any one movement, as that of extending the thumb (such as the extensors of the thumb and the ulnar flexor and extensor of the carpus) are aggregated together so that a lesion in that particular place would cause paralysis of this movement only.

I do not propose, and I have not the time, to describe all the numerous observations which have been made, but experimentally the chief have been done on the roots entering into the brachial and lumbo-sacral plexuses by Müller, Van Deen, Panizza, on frogs; by Peyer, Krause, on the rabbit; by Risien Russell on the dog; and by Ferrier and Yeo, Forgues and Sherrington, on the monkey. Anatomically the question has been worked out by Herringham and Paterson by dissection, and clinically by Erb, Thorburn, and many others. I also myself read a paper before the Royal Medical and Chirurgical Society in 1885, on cases illustrating localization in the spinal cord, where I showed cases of infantile paralysis with affection of the lower half of the pectoralis major, the triceps and the latissimus dorsi only, and other cases on brachial plexus paralysis.

The view that the cells in the anterior horns and also of the cords of the brachial plexus are arranged in a physiological order is supported by a condition already referred to—the paralysis of the pectoralis major (clavicular fibres)—for one class of movements, but not for another. In lesions of the anterior horns and of the brachial plexus, especially of the fifth cervical root, the deltoid is paralysed, and in passively advancing the humerus it will be seen that, along with paralysis of the deltoid, the clavicular fibres of the pectoralis major do not make any attempt to contract when the patient makes an effort to keep the humerus advanced. On the other hand, if the patient be directed to adduct horizontally, the clavicular fibres will contract in combination with the sternal fibres of the pectoralis major. The paralysis of a muscle from a lesion of a particular part of the anterior horns of the cord when it is associated with one set of muscles, and not of the same muscle when it is associated with another set in a different movement, would show that the anterior cornual cells had the power of grouping muscles together for a functional purpose. Against the view that each root of the plexus—and therefore presumably the segment of the cord from which it comes—when stimulated produces a well co-ordinated movement by groups of muscles acting synergically is the statement of Herringham[7] that, although both pronators must act together in one movement, the pronator quadratus is supplied by one root, and the pronator teres by a different root. Moreover, the cells supplying a single muscle in the limbs extend over two or more segments. Also no segmental grouping of any of the cell columns of the spinal cord has been detected,[8] and this condition stands in harmony with the results of the examination of the relation of the reflex movements to spinal segments.

On the whole, although the evidence is against the cells of the anterior cornua being arranged physiologically for a functional purpose, it does not follow that there is no power of co-ordination in the spinal cord. This is proved by the various complicated reflex actions which are performed when the spinal cord is cut off from the cerebral influence, reflex actions which, as in the plantar reflex, are made up of contractions of several joints in the limb. It has been found by Page May[9] and by Sherrington[10] that electrical stimulation of each posterior root produces a definite movement which acts reflexly through the anterior cornual cells. Sherrington also states that the group of cells discharged by spinal reflex action innervate synergic and not antagonistic muscles. May's observations were also made by direct excitation of the spinal cord along its postero-external column.

The movements resulting from excitation of a segment of the spinal cord in the lumbo-sacral region and those from excitation of the corresponding posterior root are similar but are never quite identical. In each case flexion is the predominating effect, but in the former case (spinal cord) the resulting movements are always stronger than in the latter (posterior root) and frequently movements in other parts (tail, perineum, etc.,) are added.

The stimulation of one posterior root causes impulses to pass out along many anterior roots, and while stimulation of the posterior roots always produced flexion, that of the anterior roots produced extension. Sherrington gives a list of the movements obtained by stimulation of all the posterior roots in the monkey. The movements resulting from stimulating a posterior root are synergic and not antagonistic, which, as Sherrington remarks, is against the theory of the action of the antagonists which we have already discussed. Sherrington[11] in his observations on the isolated length of the brachial enlargement on stimulating the skin of the palm of the hand obtained the following reflex movements:

Thumb.—Flexion, adduction.
Shoulder.—Retraction, later protraction.
Wrist.—Extension.
Elbow.—Flexion.
Fingers.—Flexion.

The mechanism by which such highly co-ordinated movements are affected is by the afferent fibres of the posterior root, which either sends branches forwards in the grey matter of the spinal cord to the neighbourhood of the cells of the anterior horns or the cells of the posterior cornua are interposed between the posterior root fibres and the anterior cornual cells. Whether for the purposes of producing such co-ordinated movements as those obtained by stimulating the palmar surface the two-cell system is sufficient, it is difficult to say, but it has been suggested[12] that the two cells are probably connected by the help of a mediate system of cells. The time at my disposal will not permit me to go into this question, but there is evidently in the cord itself a nervous organization which can produce co-ordinated movements reflexly on stimulating the skin or the posterior spinal roots, but whether the co-ordination is the same as that occurring in voluntary movements it is difficult to say. I should mention that Professor Gad was the first to ascribe to the posterior cornual ganglion cells in the frog the function of connecting together the cells for the flexors of the ankle, knee, and hip.[13]

REPRESENTATION OF MOVEMENTS IN THE EXCITABLE AREA OF THE CORTEX CEREBRI.

Time will not permit me to enumerate the various observers from the pioneers, Hitzig and Ferrier, to the present day; nor is it my intention to discuss the much-vexed question whether the so-called motor or, as it is better to call them, the excitable areas of the cortex are motor, sensori-motor, or sensory, but that they depend on sensory impressions for the power of exciting movements is shown by the remarkable observations of Mott and Sherrington,[14] who found that after dividing all the posterior spinal roots of the brachial enlargement of the cord the voluntary movement of grasping by the hand was permanently lost, while movements of the limb could be elicited with apparently normal facility by electrical stimulation of the part of the cortex where the movements of the upper limb are represented.

I wish particularly to refer to the results obtained by Sir Victor Horsley and myself on stimulation of the excitable cortex in the monkey[15] and the orang.[16] In the monkey we examined every two square millimetres of the excitable cortex, and we found in certain squares where the upper limb was represented that the co-ordinated movements of flexion of the fingers and thumb, extension of the wrist, and flexion of the elbow was obtained, and though flexion of the fingers and flexion of the wrist were also obtained in other parts of the cortex, flexion of the thumb and fingers, and extension of the wrist were much more frequently the rule. Another co-ordinated movement which was obtained was that of opening the eyes and simultaneous turning of the head and eyes to the opposite side, a combination described previously by Ferrier.

The movements obtained from stimulating the excitable area of the cortex are always co-ordinated movements and never those of single muscles unless a movement was performed by a single muscle only. The association of the extensors of the wrist with the flexors of the fingers was sufficiently frequent to warrant the opinion that a synergic association existed between those two sets of muscles.

The results which Sir Victor Horsley and myself obtained from our experiment of stimulating experimentally the cortex in the orang thirteen years ago have been in the main confirmed by the more extensive researches of Sherrington and Grünbaum,[17] who have added to the number of movements which we had found to be represented in the excitable cortex. In the one case which we examined, the representation of movements was found chiefly in the ascending frontal convolution, but we also obtained movements of the index finger, of the thumb, of the orbicularis oris, of elevation of the upper lip, and of pouting of both lips from stimulation of the ascending parietal convolution. Sherrington and Grünbaum, however, failed to get any evidence that any movement was represented in the ascending parietal convolution. In the orang the movements that we obtained were nearly always single movements, such as flexion of the elbow, flexion or extension of the thumb, and they differed from those obtained in the monkey in that the sequence of movements occurring from stimulating one spot, which Dr. Hughlings Jackson has termed the "march," was rarely obtained. The best example of this sequence of movements which we obtained in the orang was the movement of opening the eyes, followed by that of turning the eyes to the opposite side, and ending with the movement of turning the head to that side. Professor Sherrington has been good enough to inform me that they did obtain in their experiments sequence of movements, including the combination of flexion of the fingers and thumb with extension of the wrist, and though they agree with us that the representation of the movements in the excitable cortex of the anthropoid apes is much more differentiated than in that of the monkey, they did obtain evidence of the representation there of such co-ordinated movements as that of grasping.

The co-ordinated representation of muscles for a definite movement which was found to exist in the excitable cortex of the monkey is also found in the internal capsule, according to the investigations by Sir Victor Horsley and myself.[18]

In these experiments the internal capsule was cut across horizontally, and every square millimetre of its fibres was stimulated electrically. In almost every one of the experiments—which were forty-five in number—the movements were obtained of flexion of the thumb and fingers and extension of the wrist, and frequently flexion of the elbow and adduction of the shoulder.

The association between the flexion of the thumb and fingers and the extension of the wrist was most marked and occurred so often that the association must be for a synergic purpose.

The association between the flexors of the fingers and the extensors of the wrist has been well shown by some interesting experiments by Hering,[19] who stimulated electrically the cortex in the monkey about 1 mm. above the angle of the precentral sulcus, where Ferrier, and Horsley and Schäfer had produced the movements of closing the hand into a fist, and where Sir Victor Horsley and myself[20] had found flexion of the fingers and extension of the wrist. Hering first stimulated this part and produced the characteristic closure of the fist. He then cut through the tendons of the extensores carpi radialis longus et brevis, and he then obtained not only flexion of the fingers but also flexion of the wrist, owing to the absence of the synergic action of the extensores carpi radiales. Also when in place of dividing the tendons of the extensors of the wrist he divided those of the flexors of the fingers, the wrist was extended, but the fingers were not flexed, when the same part of the cortex was stimulated. Hering also performed the same experiment and got the same results by stimulation on the horizontally cut surface of the internal capsule, the fibres which we had found to give flexion of the fingers and thumb and extension of the wrist. These experiments are very strong evidence that co-ordination of synergic movements takes place in the excitable area of the cortex.

THE RELATION BETWEEN THE SPINAL CORD AND THE EXCITABLE CORTEX.

We have seen that there is in the grey matter of the spinal cord a mechanism by which on stimulation of the posterior root fibres a series of co-ordinated movements are produced, and that it is also possible in the excitable cortex to produce co-ordinated synergic movements.

The questions before us are—Does the co-ordination of the simple voluntary movements take place in the spinal cord, or in the excitable cerebral cortex only; if in the cord, is there a mechanism there which is put into action by an impulse from the excitable cortex travelling down the pyramidal tract; if there be a mechanism in the cord for receiving cortical impulses, is it identical with that for receiving reflex impulses from the skin, for the production of reflex actions; lastly, if all the co-ordination of simple movements takes place in the excitable cortex, between which and the muscles there is no intermediate co-ordinating station, then is the mechanism in the spinal cord used solely for reflex actions?

In speaking of the relation between the representation of the simple movements in the cord and in the cortex, I would ask:—Can all the reflex movements, which may be elicited by stimulation of the posterior roots or of the skin, be reproduced voluntarily? It is well known that certain reflexes, such as coughing, can be performed voluntarily, and can be inhibited and prevented from taking place, while others, like sneezing, cannot be voluntarily performed and cannot be inhibited; but, with regard to the skin reflexes, I do not know that the question has been raised, and it occurred to me to try and reproduce them voluntarily. The plantar reflex can, I think, be reproduced voluntarily, though I am not sure that the order in which the muscles contract can be exactly imitated. The cremasteric cannot be reproduced voluntarily. The abdominal and epigastric reflexes in which the middle line with the umbilicus is drawn to one side reflexly by scratching with a quill pen along the side of the abdomen cannot, I was surprised to find, be reproduced voluntarily.

My time is too short to go into the question whether some of these superficial reflexes are spinal or cerebral[21] in origin, and why they are frequently lost in hemiplegia; but assuming that they are spinal, we have co-ordinated movements produced reflexly by stimulating the skin, and which cannot ordinarily be reproduced by voluntary effort. The fact that an ordinary individual is not able to reproduce voluntarily the particular co-ordination which can be elicited as a cutaneous reflex would mean either that this particular co-ordination is represented in the cord but is not represented also in the excitable cortex, or that, if the movements obtained by exciting the cortex are also represented in the spinal cord, the mechanism by which these movements are co-ordinated is not the same as that by which the cutaneous reflexes are brought about.

At present I do not think that we are in the position to answer the question whether these reflexes are of cerebral or spinal origin; and in view of the inability to reproduce voluntarily all the cutaneous reflexes, the question will have to be worked out, supposing that the movements obtained by stimulating the cortex are also co-ordinated in the spinal cord, whether the mechanism in the cord used for cortical impulses is identical with that used for co-ordinating the movements obtained reflexly by irritating the skin.

THE RELATION OF THE EXCITABLE CORTEX WITH THE CO-ORDINATION OF SIMPLE MOVEMENTS.

As some authors have raised the question whether single muscles can be put into action by a cortical pyramidal cell, I may say at once that the results obtained by stimulation experiments and also by clinical observation of epileptic attacks and of hemiplegia due to lesions of the cortex or of the internal capsule are all in favour of the view that movements and not single muscles are represented in the arrangement of the cortical cells and of the fibres forming the internal capsule. This is the doctrine taught by Dr. Hughlings Jackson. As I therefore consider that only co-ordinated movements are represented in the excitable cortex, I will give in illustration of this view a case which I have lately seen at the Marylebone Infirmary through the kindness of Mr. Lunn. It was that of a man with recent hemiplegia—and here in passing I would remark that I do not think much can be learnt with regard to co-ordination from old cases of hemiplegia who have recovered one or two movements, but in whom there are probably secondary changes in the spinal cord. In describing this case I would recall what I said in the last lecture that in strong movements of grasping, the prime movers are the flexors of the thumb and fingers, the synergic muscles are the extensors of the carpus, and the fixation muscles are the triceps followed by the biceps.

The patient was suffering from hemiplegia, in whom, contrary to the usual course, the return of power had commenced in the hand, and he could perform the movement of grasping, but he had no power to extend the wrist or to flex or extend the elbow. On getting this patient to grasp with his full strength, I noted that, in addition to the contraction of the flexors of the thumb and fingers, there was a contraction of the synergic muscles extending the carpus and of the fixation muscle, the triceps, and that the triceps was not felt to contract till a certain strength of grasp was reached. The important point is that the patient had not the slightest power to contract the extensors of the carpus when he was told to perform the movement of extending the wrist, or of the triceps when he was told to extend the elbow. In this case, where the lesion was probably in the internal capsule, the only fibres which were available for impulses emanating from the "arm-centre" of the cortex were those coming from that part where the movements of grasping were co-ordinated, whereas the fibres conducting impulses emanating from the part of the cortex where extension of the wrist and extension of the elbow were represented were unable to pass. In other words, the patient could put into action the extensores carpi and the triceps when they formed part of the movement of grasping, but he could not make either of them contract as prime movers in extension of the wrist or elbow.

The next point is, Is the link between these three sets of muscles in the cord or in the cortex? If it be in the cortex, it would mean that there must be three sets of cells which would be co-ordinated to act together for this purpose; it would also mean that there must be separate cells for the movements of the extensors of the wrist and the elbow for their action as prime movers, and separate cells for all the different combinations. Though the cortex might be large enough to contain all these cells, it would be impossible to find room in the internal capsule, and much less in the pyramidal tract, for all the fibres that would be required. If, on the other hand, these three sets of muscles are joined together under the guidance of cells in the posterior cornu, the combination would be thrown into action by an impulse from one set of cells in the cortex.

The question is best approached by examining what takes place in the movement of lateral deviation of the eyes. If the cortex in the angle of the precentral sulcus of—let us say—the left side be simulated, both eyes move conjugately to the right; and if the corresponding fibres of the left internal capsule be stimulated, the same effect is produced: conversely, if the left cortex or the capsule be paralysed, the eyes deviate to the left. These fibres, passing through the left internal capsule and the crus cerebri, cross to the opposite side to the nucleus of the right sixth nerve, whence fibres pass over to the part of the left third nucleus, or third nerve, which presides over the left internal rectus muscle. In this case the link between the right external rectus and the left internal rectus takes place in the medulla in the sixth nucleus, as suggested by Foville. The proof of this is that, in lesions of the right sixth nucleus, without involving the third nuclei or the pyramidal tract, the same conjugate paralysis of the eyes, with deviation to the left, is produced as from a lesion of the left cortex.

Now, although these two muscles, the external and internal recti, are on opposite sides of the body this conjugate movement of the eyes is as much a unilateral movement[22] as that of closing the fist, for the reason that on stimulation of the left cortex the eyes turn to the right and not to the left. I think, therefore, that we are justified in inferring that the principle which underlies the simple movement of turning the eyes to the right can also be applied to the simple movement of closing the fist, and that the link between the three sets of muscles, the flexors of the fingers and thumb, the extensors of the carpus, and the triceps takes place somewhere below the level of the internal capsule, and by analogy in the spinal cord.

It has been shown by von Monakow[23] and by Schäfer[24] that the ending of the fibres of the pyramidal tract is in the neighbourhood of the posterior horns and not in the anterior horns as was formerly thought to be the case; von Monakow also thinks that there are intermediate cells between the anterior cornual cell and the ending of the pyramidal fibre, and that this cell has the power to bring out associated movements.

It therefore seems probable that the co-ordination or the link between the muscles entering into a simple movement takes place in the cells of the posterior cornua, which are put into action by impulses coming down the pyramidal tract from the excitable cortex where these movements are also represented. Whether the same co-ordinating mechanism in the spinal cord is used alike for reflex actions and for cortical impulses, or whether there is a separate mechanism for each, I do not think, as I said before, that we can say. Now as the most complicated and intricate muscular performances are only an arrangement of simple movements in some particular order, it is probable that in learning some new combination of movements, such as playing the violin, fencing, or golfing, the simple movements represented in the excitable cortex are in response to visual or auditory impressions brought into action in their proper combination and sequence. Later on the combination learnt with difficulty becomes by frequent practice automatic. But as these learnt combinations or even such an elementary combination as walking become automatic, there does not seem to me to be sufficient evidence that their seat of co-ordination is transferred from the brain to the spinal cord, for the reason that if there ensue a lesion of the cortex or of the internal capsule, all these so-called automatic movements are lost.

Time will not permit me to consider the part taken by the cerebellum in the co-ordination of movements.

REPRESENTATION OF MOVEMENTS ON THE SAME SIDE AS THE CORTEX STIMULATED.

I do not propose to go into the question of the representation in one hemisphere of such bilateral movements as pouting of the lips, mastication, and adduction of the vocal cords. Sir V. Horsley and myself discussed this question in our paper on the internal capsule,[25] and the matter has been exhaustively dealt with by Sir V. Horsley and Professor Gotch in their Croonian Lecture before the Royal Society.[26] The question is rather to find out what movements, if any, are produced on the same side as the cortex stimulated, and the strength of current which is required to evoke these movements. Hitzig,[27] in his first memoir, remarked that if the currents were feeble, their action was localized on the muscles of the opposite side of the body; but, if stronger, the muscles on the same side of the body were put into action. François-Franck,[28] experimenting on cats and dogs, found that weak currents produced movements of the opposite anterior limb, and, if the current be stronger, movements of the anterior limb of the same side are produced but after those of the opposite side. He also found that the movements persisted on the two sides in spite of removal of the opposite cerebral cortex, of section of the white matter of the centrum ovale, of division of the corpus callosum, of median section of the bulb or after section of one half of the cord on the same side as the cortex stimulated. He therefore considered that the movements were not caused by impulses conveyed from one hemisphere to the other, and he came to the conclusion that the association between the two sides could only take place in the spinal cord by the transverse commissures.

According to Unverricht,[29] when the motor cortex of one side—let us say the left—was stimulated in dogs, epilepsy was produced on the right and also on the left side. He also obtained convulsions on both sides when unilateral cortical extirpation or hemisection of the cord was performed, and this was, he considered, a proof that the convulsions on the same side only arise by centrifugal excitation in the spinal cord itself; but after double-sided cortical extirpation it was not possible to produce clonic contractions.

As I believe that no observations of this nature have been made on monkeys, I have made some researches with Sir Victor Horsley, who was good enough to perform the operation of stimulating electrically under ether the motor cortex in monkeys. Four experiments in all were done, and the general results obtained were as follows:

1. On stimulating the cortical "arm centre" by faradising with the bipolar method when there was 16 or 8 cm. distance between the coils, the first movement was in the arm of the opposite side.

2. On increasing the current by diminishing the distance between the coils to about 6 cm., movement was obtained in the arm on the same side as that stimulated.

3. The character of the movement on the same side was usually identical with that evoked on the opposite side, but in one case, where the movement began with extension of the fingers, it was followed on the same side by adduction of the shoulder.

4. When the cortical "leg centre" was stimulated, the movements on the same side appeared rather sooner than in the case of the arm, and in some cases as weak a current as with the coils at 12 cm. apart produced movements in the leg of the same side.

5. Epilepsy was obtained in all the cases in the arm of the opposite side; in 3 cases it was not obtained on the arm of the same side even to the coil at 4 cm., and in 2 out of the 3 cases that it was looked for in the lower limb epilepsy occurred on the same side. The first movement of the epilepsy on the same side was the same as that obtained on the opposite side.

6. On removing the excitable cortex from one hemisphere and stimulating the cortex of the other side, in two of the cases no movements were obtained on the same side as that of the cortex stimulated. In one experiment, where movements of interosseal flexion of the fingers, flexion of wrist and pronation were obtained on the opposite side, the most frequent movement on the same side was slow flexion of the fingers under deep narcosis, but under slighter narcosis the movements were the same as on the opposite side. In another experiment the only movement obtained on the same side was slow flexion of the elbow, whether the stimulation was applied to the "arm centre" or to the "leg centre." Also in this animal, when the internal capsule was exposed and stimulated, very slow flexion of the elbow was obtained on the same side when extension of the wrist and flexion of the fingers were obtained on the side opposite to the stimulated capsule; also very slight extension of the hip and knee were obtained on the same side when marked extension of the toes and flexion of the thigh and knee were obtained on the opposite side.

7. No epilepsy was obtained on the same side as the cortex stimulated, when the opposite cortex was removed.

The above experiments are hardly sufficient in number to prove for certain whether the movements occurring on the same side of the body as the cortex stimulated are evoked from the opposite cortex by means of the corpus callosum or from the endings of the pyramidal tract through the commissural fibres of the spinal cord. In two of the cases, after removing the left motor cortex, there was no movement at all in the right arm on stimulating the right cortex, although there was marked movement in the whole of the left side, and even in one case epilepsy. In another case the same movement—slow flexion of the elbow—was produced on the same side irrespective of the place stimulated, and in only one case was there any correspondence of movement between the two sides.

On the whole the experiments, as far as they go, are in favour of the theory that in the monkey the movements obtained on the same side as the cortex stimulated are produced from the opposite cortex through the corpus callosum rather than through the commissural fibres of the spinal cord, and that epilepsy is not obtained in the same side of the body as the cortex stimulated if the opposite cortex be removed.

I cannot conclude without expressing the hope that all students of anatomy may some day be taught on the living person and not on the cadaver the movements in which muscles take part.

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PROTRUDING AURICLES TREATED BY OPERATION.

BY T. G. OUSTON, F.R.C.S.,

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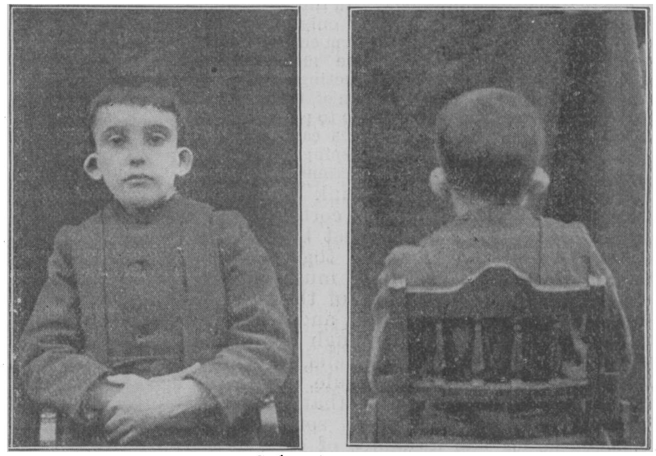
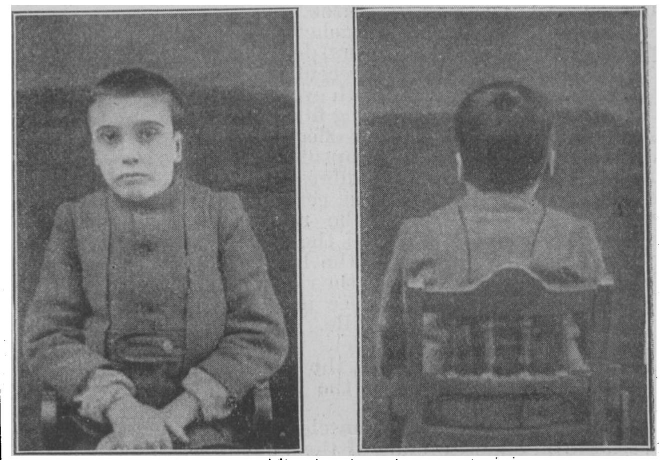
A. B., aged about 11, was brought with the request that the appearance of his ears should be improved. The condition was stated to be congenital. The margins of the pinnae curled forward considerably anterior to a vertical transverse plane taken through the centres of the external meati, and their posterior surfaces were smooth convexities instead of presenting the normal depressions. They had a large amount of spring when pressed forcibly backwards, the cartilages not even allowing of a temporary moulding into a normal shape. Under ether the following methods were adopted, each ear being operated upon on a separate occasion:

A D-shaped piece of skin $\frac{3}{4}$ in. by $\frac{1}{2}$ in., was dissected up and removed over the most prominent convexity of the posterior surface, separating easily except where the small transversus and obliquus intrinsic muscles were attached; these latter appeared to be fibrous tissue rather than muscle. The corresponding underlying piece of cartilage was cut round vertically to its surface, and the separation of its anterior surface from the front skin effected by a small periosteal separator and knife, the attachment being more intimate than on the posterior side, and the avoidance of



Before treatment.



After treatment.

button-holing the skin difficult. The pinna was now flaccid, and on pressing it backwards on to the skin over the mastoid process an accurate impression of the rawed surface was mapped out in blood; this area of skin was removed, and the posterior edges of the two raw areas united by fine sutures. In the case of the left ear the above removal of one piece of skin and cartilage proved sufficient; in that of the right sickle-shaped strips of skin and cartilage had subsequently to be removed from the still overhanging upper margin.

In a severe case anything less than free removal to the extent of taking all spring out of the auricle will result in failure.

NOTE ON THE OPERATION FOR CLEFT PALATE.

BY CHARLES P. CHILDE, B.A., F.R.C.S.,

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So many complicated and ingenious methods of passing the sutures in the operation for cleft palate have been described that I may be pardoned if I draw attention to a method which is simple, easy, and requires no special instruments.

The patient is placed in the horizontal position, with the head steadied over a firm pillow at the end of the table, the surgeon standing behind. An electric hand-light, or, better still, an electric forehead light, is requisite. The objection urged to this position is that it causes more bleeding than the